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Supreme Court of the United States.

OCTOBER TERM, 1886.

No. 113.

AMOS E. DOLBEAR, FRANCIS M. HOLMES AND HENRY B. METCALF,

APPELLANTS,

vs.

THE AMERICAN BELL TELEPHONE COMPANY.

BRIEF FOR APPELLANTS.

CAUSTEN BROWNE,
JAMES E. MAYNADIER, } *For Appellants.*

TAUNTON:
PRESS OF C. A. HACK & SON,
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THE AMERICAN BELL TELEPHONE COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES, FOR THE DISTRICT OF MASSACHUSETTS.

BRIEF FOR APPELLANTS.

This Appeal is from a final decree of the Circuit Court of the United States for the District of Massachusetts.

The Bill charges infringement of Letters Patent, No. 174,465, dated March 7, 1876, and of one other patent; but "it has been agreed that no decree shall be made in respect to the said second patent." Dolbear Record, page 729.

The Answer denies the validity of the patent, and also denies infringement.

The Final Decree was that the defendants have infringed the 5th claim of the Bell patent of 1876.

The errors assigned by the appellants are:

1st. That the Court below construed the method of the 5th claim to consist in causing electrical undulations similar in form to the sound waves.

2d. That the Court below held the 5th claim so construed to be for a patentable subject.

3d. That the Court below decided that the method and apparatus used by defendants infringed the 5th claim.

The appellants contend:

1st. That the 5th claim, as construed by the Circuit Court of the District of Massachusetts, is not for an art, machine, manufacture or composition of matter, and is therefore void.

2d. That the 5th claim, as construed by the Circuit Court of the District of Massachusetts, is not for any invention or discovery, and is therefore void.

3d. That causing electrical undulations similar in form to the vibrations of air accompanying vocal or other sounds, is not a method or an art, but simply an object to be accomplished.

4th. That the only invention or discovery possible in regard to causing such electrical undulations, was as to some method of, or apparatus for, causing them, and for using them.

5th. That transmitting articulate sounds by undulatory vibrations of electricity is not an art or a process, and is not the subject of either invention or discovery: but is merely a result to be attained, or an object to be accomplished; and that the only invention or discovery possible in relation to such result or object is of some method of, or apparatus for, attaining such result or accomplishing such object.

6th. That neither the method nor the apparatus patented by said Letters Patent of 1876 has ever been used by the appellants, nor has any method or apparatus substantially like said patented method or apparatus, ever been used by the appellants.

THE ESSENTIALS IN ALL METHODS OF TRANSMITTING VOCAL AND OTHER SOUNDS.

Vocal and other sounds are heard by reason of the action of air waves upon the drum of the ear. These air waves when produced by the vocal organs and caused in any way to act on the drum of the ear give rise to vocal sounds.

When speaker and hearer are not far apart the air waves produced by the vocal organs of the speaker extend through the air to the ear

of the hearer, and this is the natural method of transmitting vocal and other sounds, viz., by causing the proper air waves in a body of air one part of which is in contact with the vocal organs and the other part of which is in contact with the drum of the ear.

The air waves proper to produce vocal or other sounds are propagated in all directions, and probably the first improvement or modification of the natural method was an attempt to direct the propagation of the air waves to a desired point. The speaking trumpet is an example of this improvement on the natural method.

A still farther improvement in the same line is the speaking tube where the body of air between the vocal organs and the ear is separated from the surrounding air by means of a tube one end of which is near the vocal organs and the other end near the ear.

Probably the first method wholly distinct from the natural method is that practiced in the use of the mechanical telephone, where a body of air, in contact with the vocal organs and also in contact with a proper diaphragm, was set in vibration by the vocal organs, so that the energy of the air waves produced by the vocal organs caused vibrations in the diaphragm similar in form to the vibrations produced in the air by the vocal organs. These vibrations of the diaphragm near the vocal organs caused like vibrations throughout a cord or wire stretched from the transmitting diaphragm to the receiving diaphragm, and the vibrations of the stretched cord or wire caused vibrations in the second diaphragm similar in form to the vibrations of the first diaphragm. These vibrations of the second diaphragm caused vibrations in a body of air in contact with that second diaphragm and also in contact with the drum of the hearer's ear. This method differed in this striking particular from the natural method, viz., — the body of air acted upon by the vocal organs was separate and distinct from the body of air which acted upon the drum of the ear. Owing to this striking difference it is obvious that suitable means are essential in this method to cause vibrations in the distant air body which are a copy of those set up in the air body in contact with the vocal organs; and it is of some interest to note that the chief features of the means or apparatus for accomplishing this are two diaphragms,— the first vibrating under the energy of air waves set up by the vocal organs, and the second by its vibration causing air waves like those which acted upon the first.

The inventor of this method perceived first that the energy of air waves produced by the vocal organs would vibrate a diaphragm; secondly that this diaphragm could be made to vibrate a second diaphragm, at a distance from the first, by means of a stretched cord or wire connecting the two, — and thirdly, that the second diaphragm thus vibrating would cause vibrations in the second air body like those in the first air body.

Obviously one essential part of his problem was how to connect the two diaphragms so that the vibrating diaphragm of the transmitter should compel the diaphragm of the receiver to vibrate in the same way and he solved this problem by connecting the two diaphragms together by means of a stretched cord or wire.

The method which the appellants confidently submit is described fully and clearly in the Reis publications (*infra*), is copied from the method of the mechanical telephone as to its most striking feature—that is the use of two separate and distinct air bodies, the first set in vibration by the vocal organs and acting to cause vibration of a diaphragm, those vibrations of the diaphragm causing vibrations in a distant air body like those in the first air body. The method invented by Reis of causing the vibrations of the transmitter diaphragm to set up vibrations in the distant air body is wholly unlike anything in the mechanical telephone; so different that it is no detraction from the merits of Reis as an inventor to point out the fact, which seems obvious, that he borrowed the first and the last steps of his method from the mechanical telephone.

The' Reis method is this:— First, take the transmitting diaphragm of the mechanical telephone, and set it in vibration by the energy of air waves produced by vocal or other sounds, that is, cause that energy to vibrate the transmitting diaphragm precisely as in the mechanical telephone; secondly, cause the transmitting diaphragm by its vibrations to control an electric current; thirdly, cause this current to set up vibrations in a magnet, and lastly cause that magnet to set up vibrations in the distant air body like the vibrations in the first air body.

Probably it will not be disputed that Reis intended to produce vibrations in the distant air body similar in all respects to those in the first air body, that is intended to solve the same problem electrically which had already been solved in the mechanical telephone. Whether he succeeded or not is not at present under discussion. The only point now urged is that he clearly perceived and clearly described a method of

transmitting vocal and other sounds telegraphically, (1) by causing the sound to influence (2) an electric current and causing that current to influence (3) a magnet, and by causing that magnet to (4) set up vibrations in the distant air body, and thereby produce sound like the first.

The problem which Reis sought to solve was,— how shall I connect two separate air bodies by means of electricity so that vibrations set up by the vocal organs, or other sound vibrations, in the first air body, shall by means of electricity be also set up in the distant air body? He attempted — with what success it is not at this point deemed necessary to inquire or consider — to solve this problem by causing the energy of the sound vibrations in the first air body to set up vibrations in a diaphragm, which diaphragm carried one of the electrodes of a battery circuit, and by placing in that circuit a coil of wire and its core, which core was in contact with the distant air body. His theory was that the sound vibrations in the first air body would vary the current strength of the battery current, that those variations in the strength of current would, as the varying current passed through the coil, vary the magnetic energy of the core of the coil, and that the varying magnetic energy of the core of the coil would set up vibrations in the air body in contact with the core of the coil.

The speaking trumpet, the speaking tube, the mechanical telephone and the Reis telephone, constitute the state of the art; and it is manifest that no patent granted as late as 1876 can lawfully cover either of these four apparatuses, or either of the four methods practiced when either of the apparatuses is used.

These methods of and apparatuses for transmitting vocal or other sounds are here explained, mainly to sustain the proposition that long before any alleged invention of Bell the problem of how to transmit vocal or other sounds was one which had been solved more or less perfectly, and especially, that it was entirely clear before any alleged invention of Bell that in order to solve that problem these three elements were essential:—

First, some way of causing sound waves set up in an air body at one place to operate some sort of instrument now commonly called a transmitter.

Secondly, means of some sort whereby the transmitter should in some way or other control or operate—

Thirdly, some sort of instrument adapted to cause vibrations in the distant air body like those operating on the transmitter.

Or more briefly, the essentials are first — a transmitter of some sort; second—a line or connection of some sort; and third — a receiver of some sort.

THE THREE CHARACTERISTICS OF VOCAL AND LIKE SOUNDS.

The particles of air set in motion by a tuning fork are supposed to vibrate in substantially the same way as the tuning fork vibrates, that is, each air particle travels from end to end of its path a certain number of times per second, and this determines the *pitch* or *key*. A whisper differs from a shout in the *amplitude* of the vibrations just as when the tuning fork is struck the sound gradually dies away as the extent or amplitude of the vibrations diminishes, — that is, the fork vibrates with gradually lessening amplitude until it finally ceases to vibrate.

Where all the air particles in a sound wave have the same rate and amplitude of vibration a simple sound of a definite pitch and loudness is heard.

Vocal and like sounds are highly complex and the motions of the air particles forming the sound waves of such sounds are also highly complex. What the motions are of the particles in a body of air set in vibration by human speech is a matter as to which knowledge is wanting farther than that they must move to and fro in some intricate and peculiar way and must produce condensations and rarefactions in the air body intricate and highly complex in comparison with the condensations and rarefactions of simple sound waves. It is probably not material that we should be able to understand exactly the motions of the air particles in complex sound waves, as the term quality, indicating an intricate and peculiar to and fro motion of the air particles in such complex sound waves, gives a sufficiently definite understanding, especially as it is clear that rate of vibration or number per second gives the *pitch*, the amplitude or extent of vibration determines the *loudness*, and that the combination of vibrations, each having its own rate and amplitude, give the *quality*.

THE REIS METHOD AND APPARATUS.

By arrangement with counsel for the other Appellants, the Reis defence will be left mainly to be argued by them, and this defence will be now considered only so far as it is deemed to be important as a defence in the Dolbear suit.

It is submitted, first, that the Reis transmitter of the pattern shown on pages 610, 615, 623, 633, 647 and 652 of the Dolbear Record, does not differ in substance from the transmitters now in general use, except in one single respect; viz, that the electrodes are platinum in the Reis, and carbon in the transmitter in general use. This transmitter may well be called the Reis gravity transmitter, and the appellants in this case submit that the apparatus used by them was, so far as the transmitter is concerned, copied from the Reis gravity transmitter, except that the appellants use carbon instead of platinum.

Second, the appellants in this case also submit that it is proved beyond all dispute that the Reis gravity transmitter when spoken to with a moderate tone of voice causes electrical undulations similar in form to the vibrations of the air accompanying the speech waves, and that it differs in this respect from the transmitters of the commercial telephone simply in degree, that is to say, solely as a well made machine or apparatus differs from an ill made one of the same kind.

The testimony of Prof. Dolbear on pages 387-396, both inclusive, of the Dolbear Record, and of Mr. Buck, pages 487-488 is full and positive as to this.

In view of the undisputed fact that the transmitters of the Appellants' apparatus are practical working transmitters, it is certain that the Reis gravity transmitter is also a practical working transmitter, except in so far as it is defective in details of construction. For it is manifest on inspection that Appellants' transmitter is a copy of the Reis gravity transmitter. The testimony of Prof. Cross in answer to cross-int. 51-54, pages 517-518, substantially corroborates the testimony of Prof. Dolbear and Mr. Buck.

Cross-Int. 53. You are aware, are you not, that the Reis transmitter is, under certain conditions as to intensity or loudness of sound, adapted for use under what you call the Bell method?

Ans. It is possible, with the Reis transmitter, to produce electrical undulations similar in form to the sound waves producing them.

Cross-Int. 54. And, by electrical undulations, etc., in your answer, you mean precisely "electrical undulations similar in form to the vibrations of the air accompanying the" sound waves acting upon the tympan of the transmitter, do you not?

Ans. I do.

From all this testimony it abundantly appears, first, that there is no reason why the Reis gravity transmitter should not produce electrical undulations similar in form to the sound waves acting upon its diaphragm, provided those sound waves be not too loud; and secondly, that there is every reason why the Reis gravity transmitter should produce such electrical undulations; and that as a scientific fact the Reis gravity transmitter must inevitably produce such electrical undulations whenever vocal or other sounds not too loud, act upon its diaphragm.

The theory of "make and break" attributed to Reis, was never advanced by him, it is submitted, except as to that form of transmitter shown on page 585 of the Dolbear Record, and it is obvious on inspection that this theory is not applicable to the Reis gravity transmitter. As to the Reis receiver of knitting-needle pattern, pages 610, 615, Dolbear Record, it is clear on inspection that it is like the receiver of the commercial telephone in all substantial respects, except that the core has no armature, but this deficiency is supplied in the Reis-Legat receiver, p. 597, Dolbear Record.

It is submitted, first, that before Bell's invention, the Reis gravity transmitter, the Reis knitting-needle receiver and the Reis-Legat receiver were public property.

Secondly, that any skilled person who carefully studied the actual operation of the Reis gravity transmitter when in circuit with either of the old receivers would have been thereby informed as to the method used when this apparatus was used, and would necessarily have perceived that this method was precisely what the complainants assert that the Bell method is, whenever the vocal or other sounds acting on the diaphragm of the Reis transmitter were not loud enough to break the contact.

Thirdly, no man makes an invention or discovery who does no more than describe clearly how a known apparatus operates, whether

the true mode of operation of that apparatus were before known or not.

The fact that the Reis gravity transmitter, knitting-needle receiver and Reis-Legat receiver were public property before Bell's alleged invention voids the fifth claim of the Bell patent of 1876 if that claim be construed as broadly as the complainants contend it should be construed; for the complainants' construction of the fifth claim of the 1876 patent is, that it is for a method or mode of operation which it is now clear was necessarily used whenever the Reis gravity transmitter was in circuit with either of the Reis receivers, and the vocal or other sounds acting upon the diaphragm of the transmitter were not unduly loud.

Bell's alleged invention or discovery dwindles, in this view, to the mere perception of how the Reis apparatus operates.

BELL'S FIFTH CLAIM.

"The method of, and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

The 5th claim is two claims in one, viz., first, a claim for a certain method; and secondly, a claim for a certain apparatus.

The claim for the apparatus is for "the apparatus for transmitting vocal or other sounds telegraphically, as herein described [that is to say] by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, *substantially as set forth.*" This means the *described apparatus* for transmitting vocal or other sounds telegraphically by causing electrical undulations similar in form, etc.

And so the method is a method of "transmitting vocal or other sounds telegraphically, as herein described, [that is to say] by causing electrical undulations, similar in form etc., *substantially as set forth.*" This means the *described method* of transmitting vocal or other sounds telegraphically by causing electrical undulations similar in form, etc.

The plain grammatical construction of the language of the claim requires this. In each case, the result to be accomplished is the

telegraphic transmission of speech by causing electrical undulations similar in form, etc. The claim is for *the apparatus* for producing this result, and for *the method* of producing it.

The patented method, therefore, is not "causing electrical undulations similar in form," etc., but the described method of doing it for the purpose of transmitting vocal or other sounds telegraphically.

The method and the apparatus referred to in this claim are both found described in the paragraph of the specification [see page 49 of the Dolbear Record] which we now quote:

"Another mode is shown in Fig. 7 whereby motion can be imparted to the armature by the human voice or by means of a musical instrument. The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the center of a stretched membrane *a*. The cone *A* is used to converge sound vibrations upon the membrane. When a sound is uttered in the cone, the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion and thus electrical undulations are created upon the circuit *E*, *b*, *e*, *f* and *g*. These undulations are similar in form to the air vibrations caused by the sound, that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f*, influences its armature *b* to copy the motion of the armature *c*. A similar sound to that uttered into *A* is then heard to proceed from *L*."

Now, no "method" *eo. nomine*, is described in this passage, but doubtless the method described in the 5th claim consists *in the operations performed* by the apparatus described in the passage quoted, whether those operations be performed by the means there described or by other means, whether they are the same, viewed as mechanical means or not, so long as they perform the same *functions* which the particular means described perform.

This *is* a patentable art or method, as distinguished from a patentable apparatus, viz., *doing* the things described, as distinguished from the described *means* of doing them.

Now the operations described in the passage quoted are these, a sound is uttered so that magnetic variations similar in form to the air vibrations caused by the sound shall be created; electrical undulations upon the line, similar in form, etc., are thus created; these

electrical undulations are converted again into magnetic variations, and these magnetic variations are converted into audible sound waves.

By this method or mode of proceeding or series of operations, the telegraphic *transmission* of vocal or other sounds is accomplished; that is to say, sounds uttered at the transmitting station are heard at the receiving station.

The 1876 patent defines the terms "intermittent" and "pulsatory" as applied to an electric current, and distinguishes between vibratory or undulatory currents and intermittent or pulsatory currents.

The invention is said to consist in the employment of the vibratory or undulatory current of electricity, and it is pointed out that these "undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity, or are alternately positive or negative."

It is explained that under proper conditions "an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond in rapidity of succession to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration." "Electrical undulations induced by the vibration of a body capable of inductive action can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body, that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration, that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body, that is, to the condensations and rarefactions of the air produced by the vibration."

"The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c. indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity."

Several ways of producing undulatory currents of electricity are then explained, all of which were old and well known long before 1876.

Nothing whatever is said in the patent as to utilizing the energy of sound waves for any purpose whatever, except as follows:—

"One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. (That is as the reed of an accordeon is vibrated.) Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

"The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane *a*. A cone A, is used to converge sound vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E, *b*, *e*, *f*, *g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L."

Assume now that the writer of this specification was familiar with the Reis method and apparatus in which the undulatory current is of that kind in which "the successive impulses have all the same polarity," and that he wished to carefully distinguish the Reis electrical undulations similar in form to air vibrations accompanying vocal or other sounds, from the electrical undulations which were alleged to be new. Then it would be natural and proper to set forth, first, that in the Reis undulatory current the successive impulses all have the same polarity, whereas the undulatory currents produced in Fig. 7 are alternately positive and negative; that the undulations of the current in Reis correspond in rate of rise and fall of current strength to the pitch of the sound produced, in degree of rise and fall to the loudness of the sound, and that a rise in current strength corresponds to a condensation, and a fall of current strength to a rarefaction of air, or *vice versa;* while the undulatory or vibratory currents in Fig. 7 are widely different from the Reis undulatory current because alternately positive and negative, and because the rate of oscillation or change of polarity corresponds to the pitch of the sound produced, the intensity of each plus and minus current varies with the loudness of the sound and the positive currents correspond to the condensations

and the negative to rarefactions, or *vice versa*. To make the comparison more distinct: In Reis the successive impulses have all the same polarity, and in Bell they are alternately positive and negative. In Reis there is but one current; in Bell numberless currents. In Reis the rate of change of current strength determines the pitch; in Bell the rate of change of polarity. In Reis the change of current strength determines the loudness of the sound; in Bell the strength of the positive and negative currents generated. In Reis the condensations of air correspond to increases of current strength; in Bell to positive currents. In Reis the rarefactions of air correspond to decreases of current strength; in Bell to negative currents.

Moreover — and this is a distinction of great importance — the alternately positive and negative currents of Bell are generated by the energy of the air vibrations accompanying the vocal or other sounds, while in Reis the variations of current strength are due to, but not generated by, the energy of the air vibrations, — that is, the energy of Bell's alternately positive and negative currents is necessarily less than the energy of the air vibrations, which latter energy is slight; whereas in Reis the electric energy utilized may be many times greater than the energy of the air vibrations. (See p. 206.)

It is submitted that Bell's fifth claim should be construed, in view of the state of the art, to cover only that method of transmitting vocal or other sounds telegraphically which is described in his patent and illustrated in Fig. 7 of his drawings, that is, first, by causing the sound waves to produce magnetic variations and thereby electrical currents alternately positive and negative, similar in form to the vibrations of the air accompanying the said vocal or other sounds, by reason of the fact that the positive currents represent condensations and the negative currents rarefactions of the air, or *vice versa*; that the rate of change from positive currents to negative currents represents the rate of the air vibrations, and the intensity of each positive or negative current represents the intensity of each condensation or rarefaction. Secondly, after thus causing these peculiar alternately positive and negative currents, transmitting them to the receiver and there converting them into magnetic variations similar in form to these varying alternately plus and minus currents, and finally, by means of these magnetic variations, setting up vibrations in a distant air body, like

"One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. (That is as the reed of an accordeon is vibrated.) Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

"The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane *a*. A cone A, is used to converge sound vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E, *b*, *e*, *f*, *g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L."

Assume now that the writer of this specification was familiar with the Reis method and apparatus in which the undulatory current is of that kind in which "the successive impulses have all the same polarity," and that he wished to carefully distinguish the Reis electrical undulations similar in form to air vibrations accompanying vocal or other sounds, from the electrical undulations which were alleged to be new. Then it would be natural and proper to set forth, first, that in the Reis undulatory current the successive impulses all have the same polarity, whereas the undulatory currents produced in Fig. 7 are alternately positive and negative; that the undulations of the current in Reis correspond in rate of rise and fall of current strength to the pitch of the sound produced, in degree of rise and fall to the loudness of the sound, and that a rise in current strength corresponds to a condensation, and a fall of current strength to a rarefaction of air, or *vice versa;* while the undulatory or vibratory currents in Fig. 7 are widely different from the Reis undulatory current because alternately positive and negative, and because the rate of oscillation or change of polarity corresponds to the pitch of the sound produced, the intensity of each plus and minus current varies with the loudness of the sound and the positive currents correspond to the condensations

and the negative to rarefactions, or *vice versa*. To make the comparison more distinct: In Reis the successive impulses have all the same polarity, and in Bell they are alternately positive and negative. In Reis there is but one current; in Bell numberless currents. In Reis the rate of change of current strength determines the pitch; in Bell the rate of change of polarity. In Reis the change of current strength determines the loudness of the sound; in Bell the strength of the positive and negative currents generated. In Reis the condensations of air correspond to increases of current strength; in Bell to positive currents. In Reis the rarefactions of air correspond to decreases of current strength; in Bell to negative currents.

Moreover — and this is a distinction of great importance — the alternately positive and negative currents of Bell are generated by the energy of the air vibrations accompanying the vocal or other sounds, while in Reis the variations of current strength are due to, but not generated by, the energy of the air vibrations, — that is, the energy of Bell's alternately positive and negative currents is necessarily less than the energy of the air vibrations, which latter energy is slight; whereas in Reis the electric energy utilized may be many times greater than the energy of the air vibrations. (See p. 206.)

It is submitted that Bell's fifth claim should be construed, in view of the state of the art, to cover only that method of transmitting vocal or other sounds telegraphically which is described in his patent and illustrated in Fig. 7 of his drawings, that is, first, by causing the sound waves to produce magnetic variations and thereby electrical currents alternately positive and negative, similar in form to the vibrations of the air accompanying the said vocal or other sounds, by reason of the fact that the positive currents represent condensations and the negative currents rarefactions of the air, or *vice versa*; that the rate of change from positive currents to negative currents represents the rate of the air vibrations, and the intensity of each positive or negative current represents the intensity of each condensation or rarefaction. Secondly, after thus causing these peculiar alternately positive and negative currents, transmitting them to the receiver and there converting them into magnetic variations similar in form to these varying alternately plus and minus currents, and finally, by means of these magnetic variations, setting up vibrations in a distant air body, like

the vibrations caused in the air body in contact with the vocal organs or other source of sound.

It is certain that Bell first taught the world these similarities between the alternately positive and negative currents and condensations and rarefactions of air vibrations; and it is also certain that he is not the first to teach the world that electricity in order to do a desired work must be somehow or other fitted to do that work.

It is also certain that any skilled person who studies the Reis apparatus sufficiently to understand it, will see in it a method of causing electrical undulations similar in form to the vibrations of air accompanying the vocal or other sounds acting on the diaphragm of the transmitter.

The complainants are understood to contend that the fifth claim should be construed so broadly as to cover all methods of transmitting vocal or other sounds by electricity, no matter what property of electricity be utilized and no matter how that property be utilized. This is not, of course, the phraseology that the complainants would use to express their fifth claim, for it is probably too plain for dispute that a claim as broad as this is void.

But the claim that the complainants are understood to make is in substance that the fifth claim covers all methods, the first step of which is to set in vibration an electrical current, or to generate vibrating currents alternately positive and negative, or otherwise to make electric energy correspond to the energy of air vibrations accompanying vocal or other sounds,—the second step being to transmit this electrical energy to the desired place,—the third step being to use it, no matter how the electricity is fitted for its work, no matter how it is transmitted, and no matter how it does its work.

It is submitted that this claim is in substance as broad as the first broad claim suggested, and void for the same reasons. It is submitted that no invention or discovery is possible at all until after this so-called method or process is clearly in mind, for obviously if one approach the problem of the electrical transmission of speech he will readily apprehend that he must in some way cause speech to fit electricity for its work of transmitting speech; next he must in some way transmit the electricity thus fitted to the point where he desires to use it; and thirdly, he must in some way utilize the electricity thus fitted and

transmitted to produce speech waves like the first. But so far he has invented or discovered nothing whatever.

For example, it is clear that in order to make aerial navigation possible the air ship must in some way be elevated to the desired altitude and then in some way propelled, and then in some way lowered to its destination. While all this is clear, it is by no means an invention or discovery of any method of, or apparatus for, travelling through the air. In order to make any invention or discovery as to telephony it is necessary to find out how to cause sound waves to fit electricity for its work, how to transmit electricity to the desired point, and how to utilize it there to make other sound waves like the first. Possibly one or more of these steps may be obvious after the unknown ones are found out.

In this particular case the appellants contend that a method involving these three steps was within the reach of all skilled persons who cared to look for it, that is, the Reis method; which is, first, cause the sound waves to act upon a diaphragm which controls electrodes of a battery circuit and thereby fit the electric current for its work; second, transmit that current thus fitted in the usual way, and third, cause that current to flow through a coil of wire surrounding a magnet and thereby cause the magnet to vibrate in such a way as to make the vibrations desired in the second air body.

But suppose that no man had ever approached the problem before Bell, still it would seem clear that Bell must find out some way to cause the sound waves to either generate or control electricity, and that the way he found out must be the first step of any method or process which he could patent. It so happens that the state of the art was such that he had no difficulty in determining how to transmit the alternate positive and negative currents which he found out how to generate by the energy of the sound waves to the point where he desired to use them, nor any difficulty in finding out how to use them after they were thus transmitted, because he adopted the usual and common way of a circuit for their transmission and their conversion into magnetic energy in order to utilize them, that being the familiar and common way of transmitting and utilizing all electric currents. But there is not a single word in his 1876 patent tending to show that he had ever thought at all that an electrical current, having always

the same polarity and varying only in strength, could be in any way made similar in form to the vibrations of air accompanying vocal and other sounds. No doubt he did know this because doubtless he was familiar with the Reis method and apparatus. But it is certain that he never invented or discovered this. And it is submitted that he carefully refrained in his 1876 patent from hinting at any similarity between an electric current always of the same polarity and air vibrations.

In the Spencer case, Judge Lowell construed the 5th claim as "for a process, or method, the essential elements of which are the production of undulatory vibrations of electricity to correspond with those of the air, and transmitting them to a receiving instrument capable of echoing them," and defined Bell's invention as nothing less than the transfer to a wire of electrical vibrations like those which a sound has produced in the air; and it was decided in the Dolbear case that Bell discovered that articulate sounds could be transmitted by undulatory vibrations of electricity, and invented the art or process of transmitting such sounds by means of such vibrations.

These expressions are thought to be broader in terms than the 5th claim of the '76 patent, for the reason that that claim refers to the method "as herein described," and "substantially as set forth"; but such construction is not thought to be broader than that contended for by the complainants, and assumed throughout the testimony on behalf of complainants as the proper construction of the 5th claim.

If there be one single question upon which this case depends, it is, probably: What did Bell discover or invent?

Did he invent the transfer to a wire of electrical vibrations like those which a sound has produced in the air?

Did he invent the production of undulatory vibrations of electricity to correspond with those of the air, and the transmitting them to a receiving instrument capable of echoing them?

Did he discover that articulate sounds could be transmitted by undulatory vibrations of electricity?

Did he invent the art or process of transmitting articulate sounds by means of undulatory vibrations of electricity?

Take first, the transfer to a wire of electrical vibrations like those which a sound has produced in the air. Is that an invention or discovery?

In order to consider this, assume that Reis had not been born, and that no one had ever considered, in any way, the problem of transmitting vocal or other sounds by electricity, and that Bell was the first to attack that problem. Is it not plain that, at the very beginning of his efforts to discover or invent a method of transmitting vocal or other sounds by electricity, he must have formed some theory as to how the electricity which he hoped to use should be fitted to do its work?

As a student of electricity, he was familiar with the use of a wire as a means of causing an electrical current, or a number of electrical currents, fitted for their work at one place, to do their work at a different place, and so far, his work was easy, and involved nothing resembling invention, or discovery, but mere selection.

As an electrical student, he was also familiar with that way of causing an electrical current, or a number of currents, to do work which consists in causing that current, or those currents, to flow spirally around a coil of iron, and thereby produce magnetic energy which magnetic energy would vary precisely as the current or currents varied in strength.

Here, then, was a way to utilize the electrical current, or a number of currents, if by any means or method Bell could fit them to do the desired work.

Under the assumption that Bell was the first to attack this problem, this method of utilizing a current, or a number of currents, seems clearly an invention or discovery, for the reason that, by the hypothesis, no one else had ever thought of using magnetic energy varying in such a way as to cause vocal or like sound-waves.

But, after having a clear idea how to transmit, and how to utilize an electric current, or a number of currents, the problem still remained how to fit such current, or currents, to do the desired work, and it is highly probable that his solution of this latter problem is what mainly gives Bell his high rank as an inventor or discoverer.

Bell knew, of course, and without anything resembling invention or discovery, that the electricity utilized at the receiver must be fit to do its work;— for this is a truism,— and his knowledge of sound-waves taught him that the magnetic energy utilized at the receiver must be such as to give to and fro motions to the air particles set in

motion at the receiver, substantially the same as the to and fro motion of the air particles which actuated the transmitter.

Is it not certain that Bell might have perceived that the electricity in the line which he hoped to use must necessarily be like, in form, to the sound-waves, before making any invention or discovery, whatever?

No matter how clearly he perceived the necessity for the likeness of the sound-waves in air to the electrical sound-waves, he had certainly not made any invention or discovery until he found out, that is invented or discovered some method of, or some apparatus for, causing the sound-waves in air to either generate currents which should be like sound-waves in air, because generated by them, or else to cause sound-waves in air to vary a current from some generator, which variations in current should be like sound-waves in air, because caused by them.

It is, therefore, submitted that "the transfer to a wire of electrical vibrations like those which a sound has produced in the air" is not and cannot be either an invention or discovery, but is and must be *an object or result to be accomplished;* and that the only invention or discovery possible in relation to this object or result is some method of or some apparatus for accomplishing it.

For example, I desire to cause light-waves which act upon the retina of my eye to act upon the retina of an eye at a distant place, so that an observer there may see what I see here; is it not obvious that if I do this by electricity I must cause the light-waves, in some way, to fit electricity to do its work? Is it not perfectly plain that the only possible way to do this is to produce electrical waves resembling light-waves as closely as possible, and transmit those electrical waves, thus fitted for their work, to some sort of apparatus adapted to produce light-waves like the first, when set in motion by the electrical energy which resembles the light-waves by which it was generated or varied?

While I perceive all this clearly it is nevertheless plain that I have not so much as begun to make any invention or discovery whatever in relation to it. I must find out, that is, invent or discover some way, that is, some method of, or apparatus for, causing light-waves to generate or control electricity, and causing electricity thus fitted for its work, to produce light-waves like the first.

For like reasons, it is submitted that the production of undulatory vibrations of electricity, to correspond with those of air, is not and cannot possibly be, an invention or discovery but is, and must be, a *result* which is to be attained by some method, or apparatus which may be invented, or discovered, and that the "transmitting such vibrations of electricity to a receiving instrument capable of echoing them" is not and cannot be invention or discovery, but merely results (two results, first, transmitting; second, utilizing) which are to be attained by some act of invention or discovery.

It is also submitted that there is no other proof "that Bell discovered that articulate sounds could be transmitted by undulatory vibrations of electricity", except the fact that he found out, that is, invented, or discovered, some way, that is, some method of, or apparatus for doing it. That is to say, that his invention, or discovery, is plainly not that a certain thing could be done, but that it could be done by a certain method of, or apparatus for, doing it.

Giving the very broadest possible scope to Bell's invention, or discovery, and assuming, as before, that he was first in the field, it is submitted that his invention, or discovery, is not "that articulate sounds could be transmitted by undulatory vibrations of electricity;" for the reason that that is not, in its nature, capable of being invented or discovered; but rather underlies all invention, or discovery, resting solely in theory or hypothesis, until after some method of, or apparatus for producing currents fit for that work, has been invented, or discovered; and until after some method of, or apparatus for, utilizing currents fit for that work has been invented, or discovered.

Bell thought that he could transmit articulate sounds by undulatory vibrations of electricity, or else he never would have tried to do it. That is, thinking that it could, or might be done, he set to work to do it, and all the invention or discovery he ever made was in finding out the way to produce and utilize the undulatory vibrations of electricity as described in his patent.

It is also submitted that "the art, or process," of transmitting articulate sounds by means of undulatory vibrations of electricity is not, and cannot possibly be, either an invention or discovery, for the reason that transmitting such sounds by means of such vibrations is a mere problem, not an art, or a process.

The question for the inventor, or discoverer, is "How shall I transmit such sounds by means of such vibrations?" That is, "How shall I cause sound-vibrations to cause proper electrical undulations, or vibrations, and how shall I utilize such electrical undulations, or vibrations, after I have caused them?"

No art, or process, of transmitting light-waves by means of electrical waves similar in form to the light-waves, is yet known; but it is not unlikely that an art, or process, of doing this will be invented or discovered; and it is certain that when any art or any process of doing this shall be invented or discovered; it will be because it has been found out *how* to so apply the light-waves as to cause electric waves similar in form to the light-waves, and *how* to so apply such electric waves as to cause a second set of light-waves like the first. (See ints. 4 and 5, Dolbear's deposition, pp. 343-4.)

Certainly, it is not invention, or discovery, to perceive that articulate sounds can be transmitted by vibrations of electricity, adapted in some way, to do that work; and no man has shown any art, or process of transmitting such sounds, who has simply announced,—what is entirely obvious,—that electricity will do it, if adapted to do it; or simply announced the electrical and other conditions necessary to its being done.

Morse invented a method of, and apparatus for, writing at a distance. His method was to control an electric current so that it was fitted to produce magnetic energy of a desired intensity and duration to hold a stylus upon a moving strip of paper.

He discovered that writing could be done at a distance by proper currents of electricity, and he attempted to broaden his claim, just as it is submitted the appellees here attempt to broaden the 5th claim of the Bell patent. But this court decided that Morse's patent must be limited to what Morse had invented or discovered, and that it did not include any and all ways, whatsoever, of accomplishing this same result.

Suppose that Bell's '76 patent set out fully and clearly (as indeed it does), that sound-waves could be utilized to produce currents whose polarity varied exactly in accordance with the condensations and rarefactions of the air constituting the sound-waves, by first converting the energy of the sound-waves into magnetic energy, and then con-

verting that into electric energy in the form of transient currents, and that these currents could be utilized by being again converted into magnetic energy; and also described one form of apparatus adapted for use in practising this method, and contained a claim, in substance as follows:

"6th. I do not propose to limit myself to the specific method, or apparatus, described in the foregoing specifications, or claims, the essence of my invention being the use of undulatory currents, like, in form, to sound-waves, for causing sound-waves like the first, at any distance; however such currents may be developed, being a new application of electricity of which I claim to be the first inventor, or discoverer."

Is not such a claim, in substance, the same as the 5th claim as it has been construed by the Circuit Court in this case, and as the complainants now contend the 5th claim should be construed, and is it not plainly void, under the authority of *O'Rielly vs. Morse*?

"It has always been held that the patent embraces nothing more than an improvement [*invention*] described and claimed as new, and that anyone who afterwards discovered a method of accomplishing the same object, substantially and essentially differing from the one described, had a right to use it. Can there be any good reason why the art of printing [*talking*] at a distance, by means of the motive power of the electric or galvanic current, should stand on different principles? Is there any reason why the inventor's patent should cover broader ground? It would be difficult to discover anything in the act of Congress which would justify this distinction. The specification of this patentee describes his invention or discovery, and the manner and process of constructing and using it; and his patent, like the inventions in the other arts above mentioned, covers nothing more."

"He must describe the manner or process, as above mentioned, and the end it accomplishes. And anyone may lawfully accomplish the same end, without infringing the patent if he uses means substantially different from those described."

The appellants submit that all that Bell invented or discovered, so far as concerns his '76 patent, was that condensations or rarefactions of sound-waves could be utilized, substantially as described in his

patent, to vary the energy of the magnet, and that these variations of magnetic energy would induce electric currents, one current for each condensation, and one for each rarefaction, and otherwise corresponding to the rarefactions and condensations of the sound-waves; that such currents could be transmitted through a distant coil, and thereby be converted into magnetic energy like the first, and that this second varying magnetic energy would produce sound-waves like the first.

This is both invention and discovery, for he invented means or apparatus, and he discovered that the energy of the sound-waves would in fact, be sufficient, when converted into magnetic energy to induce vibrating currents sufficient to generate new magnetic energy, which was sufficient to cause a second set of sound-waves like the first.

His invention or discovery is the transfer to a magnet by the energy of sound-waves of magnetic vibrations like those which a sound has produced in the air, the production thereby of vibrating currents whose vibrations are like those which a sound has produced in the air, transmitting them to a receiving instrument, and producing by them another set of magnetic vibrations like those which a sound has produced in the air, and by that second set of vibrations producing sound-waves like the first.

Bell discovered that articulate sounds could be transmitted by undulatory vibrations of magnetism converted into electrical currents, when those currents were converted again into magnetism; and invented the art or process of transmitting such sounds by means of (1) such magnetic vibrations, (2) such electric vibrations, (3) such second set of magnetic vibrations.

"The method of transmitting vocal or other sounds telegraphically as herein described, by causing electrical undulations, similar in form to the vibrations of the air, accompanying the said vocal or other sounds, substantially as set forth," must mean, it is submitted, the method described in the patent and which is practiced, when Fig. 7 is used, that is, the method which consists essentially in (1) sound; (2) magnetism; (3) currents; (4) magnetism; (5) sound; first, because Bell never invented or discovered any other method; and second, because there is no hint or suggestion of any other method anywhere in his '76 patent; for all the apparatus and all the methods

described in the patent, except only Fig. 7, and the method practiced when that apparatus is used, begin with mechanical energy, that is, vibrating a reed with a blast of air or by a blow or a fiddle-bow, in the common and familiar way of vibrating a reed. That is, the other method is first mechanical energy, and not the energy of sound-waves; second, magnetic energy and so on, this method being radically different from the method in the 5th claim, because it is not a method of utilizing the energy of sound-waves, but a method of utilizing the energy applied by the blast of air, or the blow, or the fiddle-bow.

THE COMMERCIAL TELEPHONE.

It turns out that the Bell method ((1), sound; (2), magnet; (3), currents; (4), magnet; (5), sound,) is of comparatively small commercial value, because of the weakness of the currents. A very much better method is now in general use. That method may, for brevity, be called the Reis–Bell method, without intending in any way, of course, to admit that Bell had anything to do with inventing it, but simply because some of its steps are the same as the Bell method, and some the same as the Reis method, and, more especially, because while one of its main features is a servile copy of the Reis apparatus, it has been put into use mainly by the Bell company.

In this Reis-Bell method, the sound-waves act upon the diaphragm of a transmitter which does not differ from the Reis transmitter, except as a well-made sewing machine, for example, differs from an ill-made sewing machine of the same style; thereby the energy of the sound-waves causes variations in the current flowing through a circuit, which is an exact copy of the Reis circuit, except that one of the electrodes is carbon instead of platinum, and except, also, that the circuit is only a few feet in length; and these variations of current caused by the energy of the sound-waves produce magnetic variations in the core of a coil of wire which forms part of the Reis circuit, which core and coil are copied exactly from Reis.

The varying magnetism of the Reis core is utilized, as in the Bell method, so that the Reis-Bell method is, 1st, sound; 2d, current; 3d, magnet; 4th, currents; 5th, magnet; 6th, sound.

patent, to vary the energy of the magnet, and that these variations of magnetic energy would induce electric currents, one current for each condensation, and one for each rarefaction, and otherwise corresponding to the rarefactions and condensations of the sound-waves; that such currents could be transmitted through a distant coil, and thereby be converted into magnetic energy like the first, and that this second varying magnetic energy would produce sound-waves like the first.

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"The method of transmitting vocal or other sounds telegraphically as herein described, by causing electrical undulations, similar in form to the vibrations of the air, accompanying the said vocal or other sounds, substantially as set forth," must mean, it is submitted, the method described in the patent and which is practiced, when Fig. 7 is used, that is, the method which consists essentially in (1) sound; (2) magnetism; (3) currents; (4) magnetism; (5) sound; first, because Bell never invented or discovered any other method; and second, because there is no hint or suggestion of any other method anywhere in his '76 patent; for all the apparatus and all the methods

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In this Reis-Bell method, the sound-waves act upon the diaphragm of a transmitter which does not differ from the Reis transmitter, except as a well-made sewing machine, for example, differs from an ill-made sewing machine of the same style; thereby the energy of the sound-waves causes variations in the current flowing through a circuit, which is an exact copy of the Reis circuit, except that one of the electrodes is carbon instead of platinum, and except, also, that the circuit is only a few feet in length; and these variations of current caused by the energy of the sound-waves produce magnetic variations in the core of a coil of wire which forms part of the Reis circuit, which core and coil are copied exactly from Reis.

The varying magnetism of the Reis core is utilized, as in the Bell method, so that the Reis-Bell method is, 1st, sound; 2d, current; 3d, magnet; 4th, currents; 5th, magnet; 6th, sound.

The very great advantage of this method is that the magnetic variations in the Reis core can be made many times stronger than is possible when the energy of sound-waves is converted directly into magnetic variations as in the Bell method. Hence, the variations of strength of the currents generated by the varying magnetism of the Reis core is many times greater than is possible with the Bell method; and hence, the apparatus is many times more efficient than the Bell apparatus.

This method and apparatus is here adverted to in order that the commercial telephone now in such general and common use may not be confounded with the telephone described in Bell's patent in suit.

INFRINGEMENT.

The transmitting apparatus used by the appellants is the Reis transmitter, and the Reis circuit, and the Reis coil and core, except that the Reis circuit is very much shortened, and the electrodes are carbon, and not platinum.

The pressure of the upper electrode upon the lower one is also seven or eight times more than in the Reis, and the inertia resistance seven or eight times more than in the Reis. That is, sounds loud enough to break contact in Reis are not loud enough to do that in the appellants' transmitter. But it is submitted that these changes are mere changes in details of construction, and that the Reis apparatus taken as a whole, that is, transmitter, line and receiver, does not differ from the primary circuit of appellants' apparatus, except as an ill-made machine differs from a well-made one.

The method used in the Reis portion of the Dolbear apparatus is precisely that method which any skilled person must necessarily become cognizant of from a study of the Reis apparatus, when acted upon by vocal or other sounds, not loud enough to break the circuit; and it is submitted confidently that the appellants do not infringe because of the use of this shortened Reis apparatus.

The coil and its core of the Reis circuit, as used in the defendants' apparatus, operate precisely as do the like parts in the Reis apparatus, with one exception, viz.: that the variations of magnetic energy in-

duced in the core by the flowing of the varying current spirally around the core are converted into electric variations of a kind wholly unknown until they were discovered by Dolbear. These electric variations of Dolbear are produced by variations of magnetic energy in the core of a secondary coil, and, inasmuch as secondary coils containing a core whose magnetism is varied are old and well known, it is clear that, speaking generally, the Dolbear variations are like the variations in other secondary coils; but there are, nevertheless, such marked and striking differences as make them radically new, and entitle them to rank as an invention second to none in question in this case.

In Fig. 7 of Bell's patent the coil of wire marked *b*, has one of its ends connected to the earth, E, and its other end is connected by the line wire to one end of the coil *f*, the other end of the coil *f* being also connected to the earth at *g*. This makes a closed circuit, so that any electrical current generated in the coils of *b* is neutralized instantaneously by the flow of the current in one direction or the other throughout the circuit.

The electric tension, pressure or head is necessarily small in all telephones using a closed circuit, for two reasons:

1st. The circuit is closed, and, therefore, the current of electricity can flow from the positive to the negative pole of the coil, and the pressure thereby be neutralized.

2d. The coils proper for use in this form of telephone are comparatively small.

The Dolbear secondary coil forms no part of a circuit, and, in this particular, is radically unlike Bell's Fig. 7, and the secondary coil of the commercial telephone. The fact that the Dolbear line wire is always open or broken, and never closed, prevents the flow of any current through any part of the receiver, and for this reason the electric tension, pressure, or head is at the maximum positive or negative.

In the opinion of the Circuit Court, delivered by Mr. Justice Gray are these words:

"Dolbear likewise uses an electro-magnet in the transmitter; and both his method and his apparatus, as is admitted in his own affidavit, are substantially like Bell's, until he comes to the receiver."

It is submitted that this is a mis-apprehension; and it is also submitted that both Dolbear's method and apparatus are substantially unlike Bell's in all particulars.

It is contended that his method and apparatus are substantially like Reis's method and apparatus, except as to the secondary coil, the line wire, and the receiver, and also that the Dolbear secondary coil, line wire and receiver are radically unlike anything in Bell's '76 patent, and radically unlike anything in any other telephone, and radically new with Dolbear.

But, owing to the fact that in the commercial telephone, called the Reis-Bell telephone above, there is a secondary coil connected at one end to the line wire, it seems, at first glance, that the Dolbear secondary coil and its core, connected in the same way to the line-wire is substantially like the secondary core, its coil and the line of the commercial telephone.

The appellants, therefore, earnestly urge this proposition: —

That a secondary coil, one end of which is connected to a wire, which wire is insulated, and has its free end enlarged, or, what is the same thing, electrically connected to an insulated plate, or disk, is radically unlike a secondary coil and its core forming a part of a closed circuit.

When the magnetic energy of the core of the coil varies, electric energy is induced in the coil. That is, one end of the coil is charged positively, and the other negatively.

The electric pressure, tension, or head, depends —

1st. Upon the intensity of the variation of the magnetic energy of the core.

2d. Upon the number and arrangement of the convolutions about the core.

3d. Upon the external electrical resistance between the positive and negative ends of the coil.

The greater the variation of magnetic energy, the greater the number and better the arrangement of the convolutions, and the greater the external resistance between the positive and negative ends of the secondary coil, the greater will be the electric tension, pressure or head; and where the external resistance between the positive and negative ends of the coil is infinite, as it is in Dolbear's secondary

coil, the maximum pressure possible is produced; whereas, in Fig. 7 of the Bell patent, and in the commercial telephone of the Bell Company the resistance of the line and the helix of the receiver is slight and must be slight, and, therefore, the electric tension, pressure or head never approaches the maximum.

Moreover, the secondary coils, best adapted for use in the Bell Commercial Telephone, are useless with the Dolbear receiver, for the reason that the number of convolutions in the secondary coil are far too few to produce anything like the electric tension, pressure or head essential to operate the Dolbear receiver.

To illustrate the radical difference between the Dolbear coil, line and receiver, and the coil, line and receiver of the Bell 1876 patent, or the coil, line and receiver of the commercial telephone, suppose a cylinder with a piston which normally stands midway in the cylinder. Suppose a small pipe leading from one end of the cylinder to extend to and be connected air-tight with a helical pipe surrounding a rod, and that the other end of this helical pipe be connected air-tight with a pipe which extends to the other end of the cylinder, so that whenever the piston in the cylinder is moved in one direction, a current of air flows out of one end of the cylinder through the line pipe and through the helical pipe back into the other end of the cylinder.

This is exactly analogous to the current through the Bell line and receiver in one direction.

When the piston is moved in the other direction, the air flows in the opposite direction through the line pipes and the helical pipe, and this is analogous to the flow of the current in the Bell line in the other direction. That is to say, every motion of the piston in one direction causes a current through the helical pipe and the line pipes in one direction, and every motion of the piston in the other direction causes a current through the helical pipe and the line pipes in the other direction, just as every increase in magnetic energy causes a current to flow through the helix of Bell's receiver and the line wires in one direction, and every decrease of magnetic energy causes a current to flow through that helix and those line wires in the other direction. Moreover, the number of to and fro motions of the piston corresponds exactly with the number of currents, and the amplitude of the motion of the piston corresponds with the amplitude of the currents.

If a rod be assumed to be present in the helical pipe, and it also be assumed that some form of energy be set up in this rod by the variations in the current of air flowing through the helical pipe, the analogy will be practically complete.

The Dolbear secondary coil, line and receiver cannot be so well shown by this analogy, because of its radical difference from the Bell coil, line and receiver. But, to carry the analogy as far as possible, suppose the same cylinder and the same pipes leading, one from one end, and the other from the other end of the cylinder, but take away the helical pipe, and close the free end of the pipe from the upper end of the cylinder, and the free end of the pipe from the lower end of the cylinder by caps like the nozzles of a watering pot, except that they have no perforations.

The whole system is filled with air, as before, and all the air is under a normal tension, as before, until motion is given to the piston in the cylinder; but when the piston moves in the system analogous to Dolbear's system, then a certain sort of air current is set up in the system which is closely analogous to the charging current in the Dolbear system. That is there is no flow of a current of air through the line pipe and through the receiver, because the line pipe and the cap, which constitute one member of the receiver, are air-tight, but simply an increase of pressure in the upper part of the cylinder, and in the line pipe and its cap connected with the upper part of the cylinder, and a decrease of pressure in the lower part of the cylinder and in the line pipe and its cap connected with the lower part of the cylinder. If the piston be moved a certain distance in a certain time in the apparatus analogous to Bell's, a certain current will flow; but the difference between the pressure in the upper part and the lower part of the cylinder will be simply enough to make that current flow in that time; while, if the piston be moved the same distance in the same time in the apparatus analogous to Dolbear's, the current will not be, in truth, what is commonly called a current, but simply that motion of the air particles necessary to make a uniformly increased air pressure throughout the upper part of the cylinder and the pipe and its cap connected with the upper part of the cylinder, and a uniformly decreased air pressure in the lower part of the cylinder, and the pipe and its cap connected with it.

A motion of the piston through a certain space in a certain time will give a certain current of air in the Bell, and a condensation in one part and a rarefaction in the other part of the cylinder just sufficient to make that current. If the piston be moved twice that distance in the same time, the current's strength will be double, and the difference between the condensation and rarefaction will be increased enough to double the current.

Moreover, on the very instant the piston starts to move, and begins to condense the air in one end of the cylinder, and to rarefy the air in the other end of the cylinder, the current of air flows throughout the line-pipes and the helical pipe by which the line-pipes are connected, out of one end of the cylinder and into the other end of the cylinder, thereby preventing any marked condensation or rarefaction of the air in either end of the cylinder; but in the Dolbear a movement of the piston through a certain distance in a certain time condenses all the air in one part of the cylinder and in the pipe and cap connected with that part, and rarefies all the air in the other part of the cylinder and in the pipe and cap connected with that part.

The pressure is increased a certain amount in one part, and decreased a certain amount in the other, and both the increase and decrease are the maximum possible from that amount of motion of the piston. In Bell, differences of pressure are used for one single purpose, viz: to establish the flow of currents, and the difference in pressures can never exceed that difference which is sufficient to make that flow; while, in Dolbear, the difference between the high and low pressures has no such function, because there is no flow from the high pressure end to the low pressure end of the cylinder.

The radical difference between the two is that one is a contrivance to prevent pressure by causing the current, and the other a contrivance to cause pressure by preventing the current.

In these supposed apparatuses the pistons, cylinders and line-pipes are supposed to be *fac similes*; but it is, nevertheless, contended that, owing to the presence of a helical pipe making a continuous passage for the air from one end of the cylinder to the other in the Bell, and owing to the absence of any such passage in the Dolbear, the two apparatuses are radically different throughout; for the line pipes and

the helical pipe in the Bell are mere conduits connecting one end of cylinder with the other end in the Bell; whereas, one end of the cylinder and its line pipe and cap constitutes an air chamber in Dolbear, and the other end of the cylinder and its line pipe and cap constitutes another air chamber in Dolbear, neither of which air chambers, or any equivalent for either, is found in Bell, nor is there in Dolbear any equivalent for the conduit of Bell.

To state the same thing in terms more applicable to this case, Bell shows a generator capable of developing an electric condensation at one end, and an electric rarefaction at the other end; but these two ends are connected by an electrical conduit which prevents that electric condensation or rarefaction rising to anywhere near its maximum because of the electric current which starts to flow through the conduit on the instant that any electric condensation or rarefaction commences. Moreover, the electric generators always used with, and best adapted for, the line of a commercial telephone are not adapted, even when used solely to produce electric condensations and rarefactions to produce over a few hundred positive or negative units of electrical pressure, called "volts."

In the Dolbear apparatus the generator is capable of developing electrical condensations and rarefactions measured by thousands, instead of hundreds, and there is no electrical conduit joining the ends of the generator, so that the electrical condensation at one end of the generator, and throughout the line and plate connected with that end, rises to the maximum, and the electrical rarefaction at the other end of the generator, and throughout the line and plate connected with that end, falls to a minimum.

In Dolbear there is an electrical chamber of high pressure, and an electrical chamber of low pressure, and the line wire and the plate or diaphragm electrically connected with it always forms a part of one of these chambers, and never performs the function of the line wire and helix of the Bell line and receiver; that is, never serves as a conduit connecting the high pressure chamber of the generator with the low pressure chamber of the generator; nor does the line wire and its plate or diaphragm perform any function at all like the function performed by the line wire and helix of the Bell receiver. Moreover no one knew, until taught by Dolbear, that the electric pressure

chamber, made up of the line wire and plate of his receiver could perform the function which it performs in his apparatus.

In addition to all this, it is incapable of dispute that Dolbear is the first who ever made any practical application of static electricity, that is, who ever used electric tension, pressure or head, practically, for any purpose whatever, except only in the familiar way, to cause a current through an electrical conduit.

The following is a summary of Prof. Dolbear's affidavit, on motion for an interlocutory injunction in this case, pp. 199 to 213:—

"Electricity is a physical condition of matter which is capable of manifesting itself in two ways: *first*, by attracting neighboring bodies; *secondly*, by distributing itself with great velocity throughout some substances."

A familiar way of using electricity was, years before 1876, to cause it to flow as a current and convert it into magnetism, as shown in Bell's patent.

"I feel sure that Mr. Bell did not know, nor did any one know, that electricity not converted into magnetism, but static and acting by its potential energy, could be used to produce such vibrations of a diaphragm, or indeed any continuous vibration at all.

"This is a discovery of my own, made since Bell's patent, and upon which my method of telegraphing speech is based."

He considers that his method and Bell's are "substantially different, because the electrical variations in the two cases are wholly different in character, those used by me being static or potential variations, which were not known or supposed to be available as an agent for inducing vibrations of a diaphragm, and which, when used for that purpose, do so in an essentially and radically different manner from that in which the electrical variations act which are employed by Mr. Bell. His electrical variations are in an electrical current.

"I do not convert my static electric variations into magnetic variations, because they are static and not dynamic. I use them directly and without change, to effect the vibration of the receiving diaphragm. The possibility of so using static electrical variations, or variations of electrical potential, was not known until I discovered it.

"The two methods of telegraphing speech are, I truly believe, essentially and radically different, based upon different electrical laws;

based, in my case, upon an original discovery of a capacity or power of electricity not previously known or believed to exist, i. e., the power of electricity acting through its static or potential form to attract, according to variations of its electrical potential, a body electrified to a different potential, and to thus produce sonorous vibrations."

He then considers the Bell method under several different assumptions. First, he assumes that the Bell method "consists in (1) converting the energy of the sound-waves into magnetic variations; (2) converting these magnetic variations into electric variations; (3) reconverting these electric variations into magnetic variations; and (4) reconverting these last magnetic variations into new sound-waves," and testifies that this is the method described in the Bell '76 patent as he understands it.

"I use the energy of sound-waves to control the electricity in a circuit, instead of converting that energy into magnetic variations, as Bell does; and this difference is very important practically, for the reason that all the magnetic energy Bell can get can never exceed, and practically must fall much short of the energy of the sound-waves, which is itself necessarily weak; while in this part of my method (which is not mine but borrowed from Reis) the electric energy has no relation to the energy of the sound-waves, but the electric energy used is very many times greater than the energy of the sound-waves; and this because the energy of the sound-waves is not converted into another form of energy, as in Bell's method, but is employed solely to regulate the supply of electric energy; the difference being much the same as between turning a wheel by hand thereby converting muscular power into motion, and moving water-gates by hand, thereby giving motion to the wheel. This electric energy I convert into magnetic variations, but it is the fact that any magnetic variations which can be practically obtained by converting the energy of sound-waves is wholly inoperative in my system; for my receiver will not work practically, if at all, with a magneto-transmitter. But even assuming that I do convert sound-waves into magnetic variations, and therefore must be held to employ the first step in Bell's method, how is it as to the second step? It is true in some sense that I convert these magnetic variations into electric variations;

but it is the fact that the electric variations utilized in my method are radically different from those used in Bell's method. In Bell's method variations in current strength are essential, while in my method the electric variations are static. I use magnetic variations solely to obtain great variations in potential or charge, not to obtain variations in current strength. In Bell's method the greater the variation in current strength, the better the result; in my method current variations are not utilized.

"The ends of the secondary coil, when the coil is electrified, will attract each other, and the force of that attraction will vary directly as the electric tension or potential varies, other things being equal.

"Enlarging the surface of either one of the ends will very greatly increase its attractive force, the increase in force being directly as the increase in surface, supposing the tension to be the same until the terminal receives its maximum charge.

"It is this quality of electric variations, viz., variations in electric tension or electric pressure or charge, into which the energy of the magnetic variations is converted in my method, while in Bell's method the energy of the magnetic variations is converted into vibratory currents. The difference between us in this respect is almost precisely the same as the difference between the energy of a varying current of water and the energy of a varying head of water. It is impossible to apply the electric energy active in Bell's method to work my receiver, and impossible to apply the electric energy active in my method to work Bell's receiver; and this to my mind emphasizes the difference I am now dealing with, which is, that although it is true in a sense that we both convert the energy of magnetic variations into electric energy, yet it is clear to all skilled in this art that the electric energy into which I convert the energy of the magnetic variations is a wholly different electric energy from that into which Bell converts the energy of magnetic variations; at least as different as the kinetic energy of a given number of cubic feet of water flowing from one point to a lower one in a given time is different from the potential energy of a column of water with no outlet, and so different that all will agree that it is physically impossible to utilize the potential energy of electric variations in Bell's method and equally impossible to utilize the kinetic energy of electric variations in my method.

"The above considerations of the second step of Bell's method applies in a measure to the third step which in Bell's method consists in converting the energy of electric variations into magnetic variations.

"This I omit wholly. I convert the potential energy of my electric variations directly into motion, while Bell converts the kinetic energy of his electric variations, first into magnetic energy, and that into motion. This part of my method, viz., the direct conversion of the potential energy of electric variations into sound-waves of all characters is, so far as I know or have any reason to believe, a new discovery.

"Taking the above view of Bell's method, his apparatus is in essence two magnets, two armatures, two coils and a conductor circuit of which both coils form a part. My apparatus, as most commonly used, consists of a primary circuit, containing a transmitter, a battery and a primary coil, a magnet within the primary coil, and also within a secondary coil, with the terminals of the secondary coil enlarged and opposed. It is obvious, therefore, that my apparatus lacks the magnet and its coil and armature which are in Bell's receiver. It is also the fact that the construction and operation of the coil and magnet which I use differ widely from the transmitting coil and magnet of Bell's apparatus, because my secondary coil must be of very high resistance, say upwards of 2,000 ohms (and better 5,000 than 2,000) to produce a sufficiently high charge in the secondary coil, while the transmitting coil of Bell's apparatus has in practice only a slight resistance, say about 150 ohms and is inoperative with my receiver, although especially adapted for Bell's receiver, because Bell's receiver works to the best advantage when the transmitting coil is such as to produce that current best adapted for the coil and core of the receiver; anything in excess is not only wasted, but hurtful. The resistance of the transmitting coil is an example of internal resistance, while that of the receiving coil is external resistance, and it is perfectly well known that for the maximum effect the internal and external resistance should be equal."

He next considers Bell's method as consisting "in (1) regulating a continuous voltaic current by the energy of the air waves; (2) converting the energy of this regulated current into magnetic variations,

and so on as before. His apparatus, in this point of view, will consist of a primary circuit containing a transmitter, a battery, and a primary coil substituted for the transmitting armature of his apparatus as at first considered.

"Taking this view of Bell's method and apparatus, my method and apparatus, is the same in substance so far as concerns the primary circuit, with a transmitter, battery and primary coil in it, as the like parts of the assumed Bell method and apparatus. But all that I have said as to the vastly different electric variations in the secondary coil, and the wholly different method of utilizing them, remains, of course, equally applicable here."

He next considers Bell's method as consisting "in (1) regulating a continuous voltaic current by the energy of the air wave; (2) converting the energy of this regulated current into magnetic variations; and (3) converting these magnetic variations into sound-waves, or precisely what can be learned by any student of the Reis apparatus. His apparatus, in this view, will consist of a line conductor circuit, containing a transmitter, a battery and a coil, a magnet in this coil, and an armature controlled by it. In this view, I have a conductor circuit, a battery and a coil, with a magnet in the coil, but lack the armature, and also lack any equivalent or known substitute for the armature. And my method, while the same as the assumed Bell method, so far as concerns regulating a voltaic current by the energy of the air-waves, and converting the energy of this regulated current into magnetic variations, is yet wholly different in all other respets from the assumed Bell method; for magnetic variations are wholly inoperative upon my receiver until they are converted into electro-static variations which I have fully described. Moreover, the electric variations utilized by me and which I have no doubt are wholly new with me, are widely different from any electric variations in the assumed Bell method and apparatus, as I have above fully explained."

Mr. Frank L. Pope states in his affidavit: "The method of transmitting vocal or other sounds over a telegraph line which is employed by Dolbear, resembles that described in the patent of Bell, in so far as the process of producing variations in the magnetic condition of the iron core of the inducing magnet at the transmitting station is concerned. That is to say, these variations of magnetic energy are

controlled by and are correlative with the vibrations of air-particles which are there taken up by the diaphragm or other body. But here the resemblance ends. The process of transferring this action by means of electricity to the receiving station, and of causing at that point the vibration of a resonant plate whereby the sounds are reproduced, is radically different."

Dolbear's "is a new way of using electricity as a means of transmitting sound."

"I do not find" Dolbear's method "described, indicated or suggested in any manner in the specification of Mr. Bell's patent."

"It is a method or process of using electricity to produce sound vibrations which was not only not known at the date of the Bell patent, but which nothing that was known tended, in my judgment, to suggest, but rather to exclude."

Dolbear "uses the transmitting circuit to produce a variation of electric potential, and therefore, though the first element of the apparatus of Dolbear may be identical in appearance with the first element of Bell's," [the secondary coil] "still the first step in Dolbear's process is radically different from the first step in Bell's process; all subsequent steps in the two processes being also radically different as heretofore explained."

In considering the affidavits on behalf of the defendants, on motion for interlocutory injunction in the court below, it is important to bear in mind that the defence on that motion was simply non-infringement even if the Bell patent should be construed to cover all of the three methods; that is, the Reis method (1) sound; (2) current; (3) magnet; (4) sound; or the Bell method; that is, (1) sound; (2) magnet; (3) currents; (4) magnet; (5) sound; or the Reis-Bell method; that is, (1) sound; (2) current; (3) magnet; (4) currents; (5) magnet; (6) sound.

Prof. Dolbear in his deposition in this case, pp. 341 *et seq.*, fully and clearly explains all the phenomena involved. After describing the Bell method, in answer to int. 17, p. 347, as (1) sound; (2) magnet; (3) currents; (4) magnet; (5) sound, he says, in answer to int. 18, p. 348:

"I believe this method was invented by Prof. Bell. It was a new method and of the very highest importance as compared with any

other methods for the transmission of sounds, for it was available in positions and under conditions where the use of the string telephone was impracticable, and it overcame the difficulties which had been met in the Reis system in a highly ingenious and effective manner, and rendered the transmission of speech possible on a commercial scale, and therefore it was a method of the highest degree of importance."

In answer to the 22d int., pp. 349, 350, he compares the Reis method, that is, (1) sound; (2) current; (3) magnet; (4) sound, with the Bell method, that is, (1) sound; (2) magnet; (3) currents; (4) magnet; (5) sound, and shows the very great superiority of the Bell method.

In answers 23 to 26, pp. 350, 352, he explains the Wright method which is not a method for transmitting vocal or like sounds, but only to produce sounds which resemble in pitch the sounds acting upon the transmitter. That is, the Wright method is (1) sound; (2) current; (3) magnet; (4) jumping currents; (5) sound, the last sound having no other resemblance to the first than rate per second, or pitch.

On p. 352 he describes the Reis-Dolbear method, that is, (1) sound; (2) current; (3) magnet (as in Reis); (4) tension; (5) sound.

On pp. 353 to 355 he describes the difference between static and dynamic electricity, or between electric currents and electric tension, pressure, or head.

On pp. 356 to 373 he states the substantial likenesses and differences between the Bell method and the Dolbear method.

It is submitted that these answers are remarkable for clearness and absolute fairness.

SUMMARY.

It is contended on behalf of the appellants:

I. That the Bell patent of 1876 describes and claims but one method of transmitting vocal and other sounds, which method is: (1) convert the energy of sound-waves into (2) magnetic energy; convert that into (3) vibratory currents of electricity; convert those into (4) magnetic energy; and with that cause (5) sound-waves; or briefly, (1) sound; (2) magnet; (3) currents; (4) magnet; (5) sound.

II. That Bell never invented, so far as appears from the record, any other method of transmitting vocal or like sounds.

III. That there is no hint or suggestion in Bell's patent of 1876 as to the employment of sound waves to vary an electric current (Int. 19, p. 348), nor any hint or suggestion that a current of unvarying polarity can be made capable of use to transmit vocal or like sounds; but, on the contrary, that Bell in his '76 patent takes the utmost pains to teach (what he, in fact, discovered) that, in order to produce currents in a closed circuit, like in form to sound-waves, the currents must be alternately negative and positive; that is, to and fro currents, so as thereby to copy the to and fro motions of the air particles constituting the sound waves.

IV. That Bell's apparatus is, in essence, (1) magnet; (2) coil; (3) closed circuit; (4) coil; (5) magnet, one magnet being supplied with the proper devices for causing the energy of sound-waves to vary the energy of the magnet, and the other magnet being supplied with the proper devices to cause its varying energy to produce sound-waves.

V. That Bell's patent of '76 does not cover either the Reis method or the Reis apparatus, but that the Reis method (that is, (1) sound, (2) current; (3) magnet; (4) sound) and the Reis apparatus (that is, (1) a battery; (2) its circuit; (3) a transmitter diaphragm, and the electrodes governed by it; (4) a helix; (5) its magnet) are both public property: 1st, because of the printed publications, so fully describing that apparatus, that the Reis method will necessarily become familiar to any skilled person carefully studying the operation of that apparatus; and 2d, because Mr. Bell carefully refrained from putting a single word in the specification of either of his patents which tended to show that the Reis current of unvarying polarity, but varying only in strength, was capable of being made similar in form to air-waves accompanying vocal or like sounds, and, by the very strongest implication, asserted in the '76 patent that rapidly varying polarity was essential in order that the to and fro motions of the air particles of a sound-wave should be copied.

VI. That the battery, primary circuit, transmitter-diaphragm, its electrodes, and the helix and magnet in the primary or transmitter circuit of the defendant's apparatus do not involve the method described and claimed in Bell's '76 patent, nor is the apparatus substantially the same as any apparatus described and claimed in Bell's '76 patent, but that this transmitter circuit and its parts are copied directly from Reis.

VII. That the Dolbear secondary coil, line and receiver is radically unlike anything described or suggested in Bell's '76 patent, and that the Dolbear method involved in its use with the Reis apparatus as a transmitter is radically unlike any method described or suggested in Bell's '76 patent, and is also radically unlike any method of utilizing electricity ever known before Dolbear discovered his method and apparatus.

VIII. That the fact that in both the commercial telephone and the Dolbear telephone the Reis apparatus is used as a transmitter circuit in connection with a secondary coil which forms part of the line wire, although, at first sight, it may seem to make the Dolbear telephone substantially like the Bell commercial telephone in one important particular, yet it cannot have any weight whatever in view of the radical difference between the secondary coil aud line of the Dolbear telephone and the secondary coil and line of the Bell commercial telephone, or the transmitting coil and line of Fig. 7 of Bell's patent; that is to say, Dolbear's secondary coil must be a generator of enormous electro-motive force, or electric tension, pressure, or head, while the generator of the Bell produces relatively trifling electromotive force or tension, pressure, or head; an electrical conduit joining the positive and negative poles, is essential to Bell, and fatal to Dolbear, and Dolbear's line and its connected plate, is charged to a very high potential, tension, pressure or head, alternately positive and negative, and there are no currents, properly speaking, in the Dolbear line, but only such flow as is necessary to charge the line and the plate or disk connected with it.

IX. That wholly disregarding Reis, aud assuming that Bell is the first in the field, yet the Dolbear method and apparatus is sub-

stantially unlike any method or apparatus described or claimed in the Bell patent of '76, for the reason that Dolbear does not utilize electrical undulations substantially the same as those described and claimed in the Bell patent of '76, but utilizes electrical undulations radically unlike any ever known until Dolbear discovered his method and apparatus, and for the reason that there is nothing in either the Dolbear method or apparatus copied from anything described or suggested in the Bell patent of 1876.

Respectfully submitted, by

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of Counsel for Appellants.